Environmental Impact Assessment and Air Emissions Licence for the Proposed Acetylene Gas Manufacturing Facility, located in Daleside, Gauteng

I, Gary McFadden, declare that –

General declaration:

• I act as the independent Major Hazard Installation Regulations Risk Assessment specialist in this application;
• I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessments Regulations, 2010;
• I have performed the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
• I declare that there are no circumstances that may compromise my objectivity in performing such work;
• I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
• I have complied with the Act, regulations and all other applicable legislation;
• I have not, and will not engage in, conflicting interests in the undertaking of the activity;
• I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
• All the particulars furnished by me in this form are true and correct; and
• I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signed ________________________________

18/6/2014

Date
Air Products Proposed Acetylene Production Facility Major Hazard Installation Regulations Risk Assessment Report v2.0

Ref: 0220780

June 2014

www.erm.com
Air Products Proposed Acetylene Production Facility
Major Hazard Installation Regulations Risk Assessment Report v2.0

For and on behalf of Environmental Resources Management

Approved by: Gary McFadden
Signed: [Signature]
Position: Partner
Date: 12/06/2014

Reviewed by: Gary McFadden
Signed: [Signature]
Position: Technical Signatory
Date: 12/06/2014

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EXECUTIVE SUMMARY

Air Products Limited identified the proposed Acetylene Production facility they wish to erect at Daleside, south of Johannesburg in the Gauteng Province (hereafter referred to as the “facility” or the “site”) as having the potential to affect the health and safety of employees as well as members of the public in the event of a major incident. Hence there is a need to manage the risks and ensure compliance with the Major Hazard Installation Regulations which were promulgated under the Occupational Health and Safety Act No. 85 of 1993 in 1998 and revised in 2001 (1). The current Major Hazard Installations Regulations are attached in Annex B.

The proposed Acetylene Gas production facility will be situated in the Midvaal Local Municipality, which falls within the jurisdiction of the Sedibeng District Municipality in Gauteng. The proposed development site is located on Stand 88 and 89 of Valley Settlements Agricultural Holdings at Daleside. The site is approximately 7 km to the north of Meyerton and situated between the M61 (Springbok Road) and the R 59. The site can be accessed via Tilliet Road, just off the M61 (refer to Figure 1.1). The total area of the site is 4 ha.

The site is largely undeveloped and is currently zoned for industrial purposes and is bound by Tilliet Road to the east, a manufacturing facility to the north, vacant and undeveloped land to the west and another manufacturing facility to the south.

In this Acetylene manufacturing plant, acetylene is produced by reaction of calcium carbide with water. The acetylene gas is the cleaned, compressed and filled into cylinders. These cylinders are filled with acetone and packing rings and the acetylene is dissolved in this liquid.

The Air Products Acetylene Production facility will be developed in a phased approach, with 2 defined phases:

- **Phase 1:**
  The first phase of the project will encompass 1 acetylene generator vessel, 6 compressors and 2 filling halls with a total projected production capacity of 14 400 m³/day

- **Phase 2:**
  The second phase of the project will involve the duplication of the Phase 1 section of the project and will thus involve the addition of 1 acetylene generator vessel 6 compressors and 2 filling halls which will raise the total projected production capacity of the site to 28 800 m³/day.

Major transport routes in close proximity to the site:

- The R59 Sybrand Van Niekerk Freeway is located approximately 700 m to the west of the site

There are no other registered Major Hazard Installations in the area of the proposed Air Products site.

The aim of the project was to undertake a Quantified Major Hazard Installation (MHI) Risk Assessment of the proposed Air Products site, with the objective to assess the risk to people off site via the Fatality approach.

**Fatality - Location Specific Individual Risk**

*Figure 1* represents the location specific individual risks (LSIR) for hypothetical persons located indoors. It can be seen that none of the risk contours extend beyond the proposed Air Products Acetylene Plant site boundaries.

*Figure 2* represents the location specific individual risks (LSIR) for persons located outdoors. Once again it can be seen that none of the risk contours extend beyond the proposed Air Products Acetylene Plant site boundaries.

The main reason for the differences in risk levels for those indoors as opposed to those outdoors is primarily due to the fact that the worst case scenarios of explosions involving loss of containment of acetylene gas cause high fatalities to individuals located indoors as opposed to those outdoors due to building collapses.
Figure 1 Location Specific Individual Risks of Fatality Contours for Persons Located Indoors
Figure 2  Location Specific Individual Risks of Fatality Contours for Persons Located Outdoors

[Map showing contour lines with different risk levels indicated by color codes: 1,000 cpm, 100 cpm, 10 cpm, 1 cpm. The map includes labels for North, South, East, West, and elevations, as well as coordinates for specific locations.]
**Societal Risk**

Societal Risk for the proposed Air Products Acetylene plant was calculated but the risk levels were so low that they did not appear on the FN Curve graph.

**CONSEQUENCES**

From a consequence perspective there are potential off-site effects from either Acetone pool fires or Acetylene explosions, both resulting from a loss of containment.

The following plot, *Figure 3* shows the extent of an Acetone pool fire and it can be seen that the 6.3 kW/m² radiation level does not extend beyond the site boundaries.

*Figure 4* shows that the worst case consequences, which are those posed by loss of containment of Acetylene Gas, do however result in overpressure generated by explosions extending some 82 metres beyond the proposed Air Products Acetylene Plant site boundaries to the West, 70 metres beyond the site boundaries to the North, 28 metres beyond the site boundaries to the East and only a few metres beyond the site boundaries to the South for the final double installation.
Figure 3  Area Enveloped by the Largest Acetone Pool Fire (D5)
Figure 4  Areas Enveloped by the Largest Explosion Scenario Phase 2 Double Generator Rupture
CONCLUSIONS

Due to potential incidents resulting in consequences extending beyond the proposed Air Products Acetylene Plant site boundaries from potential Acetylene explosions, the site should be considered as a Major Hazard Installation in line with the current legislation.

Environmental Resources Management Southern Africa (Pty) Ltd would declare the Air Products proposed Acetylene Plant located at Tilliet Road, Daleside near Meyerton in the Gauteng Province as a Major Hazard Installation (MHI) as outlined in the current legislation.

As a result of being declared a MHI, the Requirements of the MHI Regulations must be followed completely to ensure the proposed Air Products Acetylene Plant is legally compliant. Copies of this risk assessment must be submitted to the Local Provincial Director of the Department of Labour, the Chief Inspector of the Department of Labour Head Office in Pretoria and the Local Authorities.
1 INTRODUCTION

1.1 GENERAL INTRODUCTION

A series of major accidents at industrial installations such as fuel and gas storage, handling and production facilities have focused worldwide attention on the need to control the design and management of facilities where potential for major accidents exists. In South Africa, the Major Hazard Installation (MHI) Regulations were promulgated on the 16th January 1998 under Section 43 of the Occupational Health and Safety Act No. 85 of 1993 as amended (1), to control and manage such activities.

The MHI Regulations were revised on 30th July 2001 and they apply to:

“employers, self-employed persons and users, who have on their premises, either permanently, or temporarily, a major hazard installation or a quantity of a substance which may pose a risk, that could affect the health and safety of employees and the public.”

A requirement of the MHI Regulations is that a risk assessment needs to be undertaken by an Approved Inspection Authority (AIA), and reviewed at intervals not exceeding five years thereafter. A risk assessment is also required prior to the construction of any major hazard installation such as the new Acetylene Gas Production facility proposed by Air Products South Africa (Pty) Ltd. at Daleside south of Johannesburg in the Gauteng Province.

Normally these risk assessments take the form of Quantified Risk Assessments (QRA’s). The MHI Risk Assessment report must be submitted to the Provincial Inspector of the Department of Labour, the Chief Inspector of the Department of Labour in Pretoria and the Local Authorities for review and if necessary, for registration.

Environmental Resources Management Southern Africa (Pty) Ltd (hereafter referred to as “ERM”) is accredited by the South African National Accreditation System (SANAS) (certificate no. MHI-0012) and is a Department of Labour Approved Inspection Authority (AIA), certificate No. MHI-0008 for Major Hazard Installation Regulations risk assessments.

The certification documents are shown in Annex A. As per the accreditation requirements, this report has been reviewed by an ERM Southern Africa Technical Signatory, namely Gary McFadden.

Air Products identified the proposed Acetylene Plant (hereafter referred to as the “facility” or the “site”) as having the potential to affect the health and safety of employees as well as members of the public beyond the site boundaries in the event of a major incident involving an acetylene explosion.

Air Products currently operate 2 Acetylene Plants in South Africa. The first is located at the Air Products Spartan site in Kempton Park and the second is located at the Air Products Pinetown site. Air Products intends to decommission both of these sites when the proposed new Acetylene Plant is established.

The proposed Acetylene Gas production facility will be situated in the Midvaal Local Municipality, which falls within the jurisdiction of the Sedibeng District Municipality in Gauteng. The proposed development site is located on Stand 88 and 89 of Valley Settlements Agricultural Holdings at Daleside (the site).

The site is approximately 7 km to the north of Meyerton and situated between the M61 (Springbok Road) and the R 59. The site can be accessed via Tilliet Road, just off the M61 (refer to Figure 1.1). The total area of the site is 4 ha.

The site is largely undeveloped and is currently zoned for industrial purposes and is bound by Tilliet Road to the east, a manufacturing facility to the north, vacant and undeveloped land to the west and another manufacturing facility to the south.
Figure 1.1  Air Products Proposed Acetylene Production Facility Location
The proposed Air Products Acetylene Production facility will be developed in a phased approach, with 2 defined phases:

- **Phase 1:**
  The first phase of the project will encompass 1 acetylene generator vessel, 6 compressors and 2 filling halls with a total projected production capacity of 14,400 m³/day

- **Phase 2:**
  The second phase of the project will involve the duplication of the phase 1 section of the project and will thus involve the addition of 1 acetylene generator vessel, 6 compressors and 2 filling halls which will raise the total projected production capacity of the site to 28,800 m³/day.

The following aerial plot, *Figure 1.2* shows the Phase 1 section of the project indicated in Yellow and the Phase 2 section of the project in Green.
Figure 1.2  Air Products Proposed Acetylene Production Facility Phase 1 (Green) and Phase 2 (White)
1.2 **REQUIREMENTS OF THE MHI REGULATIONS**

The specific requirements for undertaking the QRA are set out in *Section 5* of the MHI Regulations and are summarised in *Table 1.1* (including the relevant section of this report where the requirement has been satisfied). The current Major Hazard Installations Regulations are attached in *Annex B*.

**Table 1.1**  
*MHI Risk Assessment Requirements*

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Corresponding ERM Report Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) a general process description of the major hazard installation</td>
<td><em>Section 5</em></td>
</tr>
<tr>
<td>(ii) a description of the major incidents associated with that type of</td>
<td><em>Sections 3, and 7.</em></td>
</tr>
<tr>
<td>installation and the consequences of such incidents, which shall include</td>
<td></td>
</tr>
<tr>
<td>potential incidents</td>
<td></td>
</tr>
<tr>
<td>(iii) an estimation of the probability of a major incident</td>
<td><em>Section 7.3</em></td>
</tr>
<tr>
<td>(iv) a copy of the site emergency plan</td>
<td><em>Annex E</em></td>
</tr>
<tr>
<td>(v) an estimation of the total result in case of an explosion or fire</td>
<td><em>Section 7.2</em></td>
</tr>
<tr>
<td>(vi) in the case of toxic release, an estimation of concentration</td>
<td><em>N/A</em></td>
</tr>
<tr>
<td>effects of such release</td>
<td></td>
</tr>
<tr>
<td>(vii) the potential effect of an incident on a major hazard</td>
<td><em>Section 8</em></td>
</tr>
<tr>
<td>installation or part thereof on an adjacent major hazard installation</td>
<td></td>
</tr>
<tr>
<td>or part thereof</td>
<td></td>
</tr>
<tr>
<td>(viii) the potential effect of a major incident on any other</td>
<td><em>Section 7</em></td>
</tr>
<tr>
<td>installation, members of the public and residential areas</td>
<td></td>
</tr>
<tr>
<td>(ix) meteorological tendencies</td>
<td><em>Section 4.2</em></td>
</tr>
<tr>
<td>(x) the suitability of existing emergency procedures for risks identified</td>
<td><em>Section 9</em></td>
</tr>
<tr>
<td>(xi) any requirements laid down in terms of the Environment</td>
<td><em>Section 4.3</em></td>
</tr>
<tr>
<td>Conservation Act 1989</td>
<td></td>
</tr>
<tr>
<td>(xii) any organizational measures that may be required</td>
<td><em>N/A</em></td>
</tr>
</tbody>
</table>
2 RISK ASSESSMENT & MANAGEMENT METHODOLOGY

2.1 DEFINITIONS

- A hazard is defined by the UK Institution of Chemical Engineers (IChemE) as “a physical situation with a potential for human injury, damage to property, damage to the environment or some combination of these. A major hazard is described as an imprecise term for a large scale chemical hazard, especially one which may be realised through an acute event”.

- A major hazard installation is described in the South African Major Hazard Installation Regulations as “an installation where any substance is produced, processed, used, handled or stored in such a form and quantity that it has the potential to cause a major incident”.

- A major incident is defined as “an occurrence of catastrophic proportions, resulting from the use of plant and machinery, or from activities at a workplace”.

- The process of hazard identification is described by the IChemE as “the identification of undesired events followed by an analysis of the mechanisms by which undesired events could occur”.

- Risk assessment is described as “a process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a major hazard installation and the measures needed to be taken to remove, reduce or control potential causes of such incidents”.

2.2 PROCESS OF RISK MANAGEMENT

Risk management has become widely used as a technique to aid decision-making. Five specific elements are involved:

1. **Hazard Identification:** to determine the incident scenarios, hazards and hazardous events, their causes and mechanisms.

2. **Consequence Analysis:** to determine the extent of the consequences of identified hazardous events.

3. **Frequency Estimation:** to determine the frequency of occurrence of identified hazardous events and the various consequences.

4. **Risk Summation:** to determine the risk levels.

5. **Risk Assessment:** to identify if the risk is tolerable/intolerable and to identify risk reduction or mitigation measures and prioritise these using techniques such as risk ranking and cost-benefit analysis.

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These elements are shown in the flow diagram in Figure 2.1. The elements of the procedure are used both to generate information and as an aid to decision-making in managing the risk. For decision-making, the procedure is only taken as far as is necessary to generate the information required or to make the decision. The extent of application of the various elements and degree of quantification employed therefore varies significantly from one situation to another.

Figure 2.1  Risk Assessment Process
2.3 **HAZARD IDENTIFICATION**

The first stage in any MHI risk assessment is to identify the potential incidents that could lead to the release of a hazardous material from its normal containment and result in a major accident. This is achieved by a systematic review of the facilities to determine where a release of a hazardous material could occur from various parts of the installation.

The major hazards are generally one of three types: flammable, reactive and or toxic. In this study, flammable hazards and asphyxiant hazards are relevant involving loss of containment of acetylene gas or acetone for flammable scenarios and loss of containment of nitrogen for the asphyxiant scenarios.

Flammable hazards may manifest as high thermal radiation from fires and overpressures following explosions that may cause direct damage, building collapse, etc.

Flammable hazards are present throughout the facility and associated pipelines. Fires may occur if flammable materials are released to the atmosphere and ignition takes place. The asphyxiant hazards are restricted to areas where the nitrogen is stored or used on the site.

This study is only concerned with major incident hazards as defined by the scope of the South African Major Hazard Installation Regulations (1). These regulations are concerned only with incidents which involve dangerous substances that give rise to off-site risk as far as the general public and other industries are concerned.

2.4 **CONSEQUENCE ANALYSIS**

2.4.1 *Harm Criteria for Consequence Analysis*

During the analysis it is necessary to define harm criteria (or ‘end points’) for use with the consequence models. In the case of this study, these harm criteria are levels of thermal radiation intensity and where relevant, overpressure (in the case of vapour cloud explosions).

The derivation of the harm criteria used in this study is described in Section 6.2.

2.4.2 *Consequence Modelling*

*Factors Affecting Consequences*

There are several factors which affect the consequences of materials released into the environment.

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These include (but are not limited to):

- Release quantity or release rate
- Duration of release
- Initial density of the release
- Source geometry
- Source elevation
- Prevailing atmospheric conditions
- Surrounding terrain
- Physical and chemical properties of the material released.

Such factors will affect the consequence zones for the specific hazardous materials, e.g. the distance at which the level of thermal radiation from a fire or overpressure from an explosion has reduced sufficiently so that it is no longer dangerous.

*Factors Affecting Fire Hazards*

When considering large open hydrocarbon fires, the principal hazard is from thermal radiation. The primary concerns are safety of people and potential damage to nearby facilities or equipment.

Determination of thermal radiation hazard zones involves the following three steps:

- Geometric characterisation of the fire, that is, the determination of the burning rate and the physical dimensions of the fire;
- Characterisation of the radiative properties of the fire, that is, the determination of the average radiative heat flux from the flame surface; and
- Calculation of radiant intensity at a given location.

These, in turn, depend upon the nature of the flammable material, size and type of fire, prevailing atmospheric conditions and the location and orientation of the target/receptor.

*Factors Affecting Explosion Hazards*

The explosive effect that can be produced by ignition and reaction of flammable vapour clouds in air is one of the less frequent, but potentially most severe, consequences of loss of containment. Some of the factors affecting blast overpressure hazard zones are:

- Mass of fuel involved
- Heat of combustion
- Maximum confined volume
- Explosion efficiency factor.
In addition to these parameters, the concentration of the vapour, the nature of the ignition source and the degree of confinement also contribute to the intensity of overpressure waves generated from explosions.

*Factors Affecting Asphyxiant Hazards*

The factors which can affect the dispersion of asphyxiant materials released during an incident would include

- Mass of material released
- Weather conditions at the time of the release
- Duration of exposure to the asphyxiant material released

*Consequence Models*

The hazards described above can be modelled analytically by standard models used for consequence analysis. Many of these models have been transferred to computer software and ERM has access to a range of such models.

2.5

*FREQUENCY OF MAJOR ACCIDENT HAZARDS*

For each hazard identified, the frequency is assessed.

A simple way of defining the frequency of major accident events within a QRA is to use a ‘top down’ approach. This provides frequencies of the events of interest (fires, explosions, etc.) by reference to historical accident data sources, without considering the causes or development of these events in detail.

Alternatively, if more detail is required, a ‘bottom up’ approach may be used, where the frequency of individual release scenarios is considered. The different outcomes that may result from these releases and the associated frequencies are then developed using techniques such as event tree analysis.

A release of hazardous material may be considered for a range of hole sizes, which will depend on the various causes considered. For example, a leak from a pipeline due to corrosion will tend to be small, whereas external impact, say, by a mechanical digger, is likely to produce a much larger hole.

ERM utilises the *Planning Case Assessment Guide (PCAG)* developed by the UK Health and Safety Executive (HSE). This enables an estimate of the likelihood of potential hazards following the failure of tanks, vessels, process piping, valves, flanges, etc. to be made.

The frequency of the various outcomes (accident scenarios) is then estimated by multiplying the frequency of the release by the probability of the various outcomes.
2.6 **RISK CALCULATION**

The individual risk for a specified level of harm is calculated taking the following variables into consideration:

- The frequency of the hazardous outcome (consequence), e.g. pool fire event, explosion event etc.
- The probability that the hazardous outcome (consequence) will reach the location specified (This includes variation of wind direction with consequent change to flame tilt; both downwind and crosswind distances need to be taken into account)
- Probability of an individual being at the location
- Probability of escape into shelter by an individual
- The probability that, given exposure to the hazardous outcome, the person suffers a defined level of harm.

The frequency of harm \( f_h \) being present from each hazardous outcome (consequence) event must be calculated and summed to give the maximum individual risk (IR) from all events at one location.

\[
IR_{(\max)} = \sum_{\text{for all consequences}} f_h
\]

As individual risk is location specific, the above process needs to be repeated for each location considered. The individual risk from other facilities can be summed to give the overall individual risk level from several major hazards. Calculation can be avoided if it is obvious that the event would not be able to affect a location e.g. the specified location is too far away.

The frequency of harm will be different for differing weather categories and needs to be calculated for each weather category used. The frequency of harm for a given consequence and weather category is expressed as follows:

\[
f_h = f_e \times P_w \times P_d \times P_{\text{exp}} \times P_{\text{harm}}
\]

Where:
- \( f_e \) = frequency of the hazardous outcome (consequence)
- \( P_w \) = probability of that weather category
- \( P_d \) = probability of the wind blowing in the required direction for event to affect the individual (\( P_d = 0 \) if event cannot reach a particular location)
- \( P_{\text{exp}} \) = probability of exposure
- \( P_{\text{harm}} \) = probability that defined level of harm results given that exposure has occurred

The probability of the wind blowing in the required direction depends on the angle of entrapment, or the circular sector where a particular hazardous outcome encompasses the specified location. This is a function of the distance from the source, the size, and shape of the hazard ‘footprint’.
The size and shape of the footprint is determined from the results of the consequence analysis, but gives a complex shape and is correspondingly difficult to calculate the angle of entrapment. These complex shapes are often simplified to regular shapes in order to calculate the angle of entrapment.

The frequency of harm for a specific event is the sum of the frequencies of harm for the different weather conditions:

\[ f_h = \sum_{\text{all weathers}} f_{h,\text{weather } i} \]

The stability category and wind speed combinations used in the study are discussed in Section 4.2.

ERM’s proprietary ViewRisk computer software has been used to calculate iso-risk contours, which show the geographical distribution of individual risk of harm to people.

2.7 RISK ASSESSMENT

The final and most significant step in the process is the assessment of the meaning and significance of the calculated risk levels. Risk assessment is a process by which the results of a risk evaluation are used to make judgements, either through relative risk ranking of risk reduction strategies or through comparison with established risk targets (criteria).

Where off-site risk criteria relevant to QRA have been issued (in this case based on criteria used in the UK), it is possible to assess the calculated risk levels against these criteria. This determines whether the risks are tolerable, broadly acceptable, or if risk reduction/mitigation measures are required to reduce the risk to levels which can be considered to be as low as reasonably practicable (ALARP). The risk events can then be ranked to determine the relative contribution of each to the overall risk level.

In general the higher risk events should be examined for possible areas of reduction or mitigation as a first step. Measures that prevent the potential incident from occurring should be considered first, followed by measures that reduce the probability (e.g. reduction in flanges), then measures that may limit the amount released (e.g. remotely operated valves, ROVs) and finally measures that may reduce the potential consequences (e.g. water sprays).

The risk assessment will thus enable decisions to be made on whether an investment should be made on particular mitigation measures so that the risk is effectively managed. The residual risk will then be managed by appropriate safety management systems to ensure safe operations, maintenance, good practice, etc.

The risk criteria used in this study are presented in Section 6.3.
3  

POTENTIAL MAJOR HAZARDS

This section satisfies the requirements of Section 5 (5) (b) (ii) of the MHI Regulations.

3.1  

INTRODUCTION

There are a number of hazards that will be present at the Air Products proposed Acetylene Gas production site that may result in injury to people or a fatality in more serious cases. Some hazards may even give rise to multiple fatalities. This study is only concerned with ‘major hazards’ that could affect beyond the sites boundaries, which are as follows:

- Hydrocarbon fires associated with a loss of containment of Acetone
- Vapour cloud explosions involving a loss of containment of Acetylene Gas or Acetone
- Flash fires involving a loss of containment of Acetylene Gas or Acetone
- Release of asphixiant Nitrogen due to loss of containment

Each of these hazards is described below.

Typically the release of hydrocarbons such as Acetylene or Acetone associated with the failure of equipment, e.g. a vessel hole or hose breach. This study is primarily concerned with ‘major hazards’ giving rise to off-site risk.

3.2  

HYDROCARBON POOL FIRES

The principal type of hydrocarbon fire of interest in this study is a pool fire. If a liquid release of Acetone, either from the storage vessel or the delivery road tanker, has time to form a pool and is then ignited before the pool evaporates or drains away, then a pool fire results. Because they are less well aerated, pool fires tend to have lower flame temperatures and produce lower levels of thermal radiation than some other types of fire (such as jet fires); however, this means that they will produce more smoke.

Although a pool fire can still lead to structural failure of items within the flame, this will take several times longer than in a jet fire. An additional hazard of pool fires is their ability to move. A burning liquid pool can spread along a horizontal surface or run down a vertical surface to give a running fire.

Due to the presence of kerbs, slopes, drains and other obstacles; pool fire areas and directions can be unpredictable. To provide a good conservative model, the pool fires are modelled as perfect circles.
For this study, pool-fires have been limited to the following sizes:

- Bund size for a full bund fire involving the Acetone Storage vessel
- ¼ of the bund size for small bund fires
- 100 m pool diameter for unconfined fire, reflecting the effect of uneven terrain and containment from curbs and bunds.

For cases where releases are not contained within a bund but within areas with drainage (e.g. road tanker off-loading points), those were considered contained, with the area limited by the drainage system.

3.3 **FLASH FIRES**

Vapour clouds can be formed from the evaporation of liquid pools of Acetone or from a release of Acetylene gas. Where ignition of a release does not occur immediately, a vapour cloud is formed and moves away from the point of origin under the action of the wind. This drifting cloud may undergo delayed ignition if an ignition source is reached, resulting in a vapour cloud explosion (VCE) if within confined area or a flash fire if the cloud ignites in an unconfined area. (An unconfined vapour cloud explosion is also possible under certain conditions).

The flash fire is typically modelled through simulating the dispersion of the initial cloud to the lower flammability limit (LFL). The damage area then corresponds to the LFL cloud footprint. It is also possible that pockets of gas capable of igniting travel outside the LFL cloud footprint. Therefore concentrations are also modelled to the half LFL (0.5LFL) level.

3.4 **VAPOUR CLOUD EXPLOSIONS**

If the generation of heat in a fire involving a vapour-air mixture is accompanied by the generation of pressure then the resulting effect is a vapour cloud explosion (VCE). The amount of overpressure produced in a VCE is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the vapour cloud, the number of obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

In most VCEs the expanding flame front travels more slowly than the pressure wave; this type of explosion is called a deflagration and the maximum overpressure is determined by the expansion ratio of the burning gases.

If the flame front travels fast enough to coincide with the pressure wave then the explosion is called a detonation and very severe overpressures can be produced. Detonation is most likely to occur with more reactive gases such as hydrogen and ethylene.
In this case, the generation of overpressure is considered to arise from the ignition of a vapour cloud resulting from the release of Acetylene gas to the atmosphere.

3.5 **ASPHYXIANT**

The main hazard associated with nitrogen in common with other inert gases is that of asphyxiation due to oxygen deficiency.
4 ENVIRONMENTAL SITE SETTINGS

4.1 SITE LOCATION

The proposed Air Products Acetylene Gas production facility will be situated in the Midvaal Local Municipality, which falls within the jurisdiction of the Sedibeng District Municipality in Gauteng. The proposed development site is located on Stand 88 and 89 of Valley Settlements Agricultural Holdings at Daleside (the site). (GPS coordinates in decimal degrees: -26.506631, 28.053246).

The site is approximately 7 km to the north of Meyerton and situated between the M61 (Springbok Road) and the R 59. The site can be accessed via Tilliet Road, just off the M61. The total area of the site is 4 ha.

The site is largely undeveloped and is currently zoned for industrial purposes and is bound by Tilliet Road to the east, a manufacturing facility to the north, vacant and undeveloped land to the west and another manufacturing facility to the south. The closest residential development is that of Witkopdorp (Daleside) which is located some 400 metres to the north east of the proposed Air Products site.

Major transport routes in close proximity to the site:

- The R59 Sybrand Van Niekerk Freeway is located approximately 700 m to the west of the site

The land-use around the site is shown in Figure 4.

There are no other registered Major Hazard Installations in the area of the proposed Air Products site.
Figure 4.1  Aerial Map for Air Products Proposed Acetylene Production Facility and its Surroundings
4.2 **Meteorology**

Typically, quantitative risk assessments (QRA’s) require information about the wind speed, wind direction and stability class.

Atmospheric stability is difficult to measure and often varies dramatically over relatively short distances. Atmospheric stability classes need to be defined in the dispersion modelling to facilitate estimates of lateral and vertical dispersion parameters. The preferred stability classification scheme for use in air quality modelling applications is the scheme proposed by Pasquill (1961).

The Pasquill Stability Classes are defined by the letters A to F and are described as follows:

- **A.** Extremely unstable conditions
- **B.** Moderately unstable conditions
- **C.** Slightly unstable conditions
- **D.** Neutral conditions
- **E.** Slightly stable conditions
- **F.** Moderately stable conditions.

Neutral conditions correspond to a vertical temperature gradient of approximately 1 °C per 100 m. The meteorological conditions defining Pasquill stability classes are given in *Table 4.1*.

**Table 4.1: Pasquill Stability Classes**

<table>
<thead>
<tr>
<th>Surface Wind Speed (m/s)</th>
<th>Day-time Insulation</th>
<th>Night-time Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strong</td>
<td>Moderate</td>
</tr>
<tr>
<td>&lt;2</td>
<td>A</td>
<td>A-B</td>
</tr>
<tr>
<td>2 – 3</td>
<td>A-B</td>
<td>B</td>
</tr>
<tr>
<td>3 – 5</td>
<td>B</td>
<td>B-C</td>
</tr>
<tr>
<td>5 – 6</td>
<td>C</td>
<td>C-D</td>
</tr>
<tr>
<td>&gt;6</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

It is understood that to date no weather stations in South Africa measure both wind speed and stability categories. Since no site-specific weather data were available, meteorological data (i.e. wind and stability data) from the closest weather station, namely Meyerton was sourced from the research report ‘Stability Wind Roses for Southern Africa’ (1).

The average ambient temperature and humidity for the Johannesburg area were obtained from www.weatherbase.com. A summary of the data is as follows:

- Average ambient temperature is 16.5°C and average relative humidity 65%.

ERM selected the following stability classes and wind speed scenarios for modelling purposes:

- **B3** – meaning a stability class of B (moderately unstable conditions) where the wind speed is greater than 3 m/s.
- **D5** - meaning a stability class of D (neutral conditions) where the wind speed is greater than 8 m/s.

The above weather scenarios give a conservative daytime weather condition.

- **F2** – meaning a stability class of F (moderately stable) where the wind speed is less than or equal to 2 m/s. This class is often used by the US Environmental Protection Agency for determining worse case scenarios for vapour cloud dispersion consequence analysis. F2 gives a conservative night time weather condition.

Selecting the above categories gives an average and a ‘worst case’ condition for the risk assessment study.

### 4.3 REQUIREMENTS OF OTHER ENVIRONMENTAL LEGISLATION

*EIA Regulations (GNR 543, 544 and 546 of 18th June 2010) promulgated under the National Environmental Management Act No. 107 of 1998, as amended*

A full EIA is currently being undertaken by ERM and the site will comply with all requirements of this legislation.
5

DESCRIPTION OF FACILITIES

5.1 DESCRIPTION OF SITE OPERATIONS

In a Stationary Carbide to Water type Automatic Acetylene Generator acetylene is produced by reaction of calcium carbide with water. Adequate quantity of water is held in the generator shell to which calcium carbide is fed from top.

The following reaction takes place:-

\[ \text{CaC}_2 + 2\text{H}_2\text{O} = \text{C}_2\text{H}_2 + \text{Ca(OH)}_2 + 27,000 \text{ Calories} \]

The generated acetylene gas occupies the free volume inside the generator shell over the water level and pressure of gas goes up till it reaches the set pressure level when by action of the pressure controller carbide feed motor is cut-off. If the acetylene gas is taken out from the generator, the pressure inside the generator shell will go down and by action of the pressure controller carbide feed motor will start and feed further carbide through the screw feed mechanism from the hopper into the shell and further acetylene shall be generated.

Thus the process shall continue till the carbide filled in the hopper under operation is exhausted. At that stage change over takes place and second hopper which was filled with carbide when first hopper was under operation now starts feeding carbide into the generator shell and first hopper is filled with carbide.

As the process of acetylene generation is exothermic, there is a temperature rise of the generator. The generator temperature cannot be allowed to go high because acetylene can catch fire. Moreover, generation of acetylene is optimum at a particular temperature around 60ºC. Hence it is necessary to keep the generator temperature around 60ºC.

This is done automatically by the temperature controller which is pre-set at a temperature of 60ºC. Since the generator has a tendency of increased temperature, the temperature controller acts on the water inlet valve and opens the valve to bring in fresh process water which reduces temperature of the generator and thus the generator temperature is kept at about a particular predetermined set point.

With inlet of fresh water to bring down the generator temperature the water level inside the generator goes up and this water level is maintained between a high and low set point by pneumatically operated level controller. Slurry discharge valve is made to open automatically by the level controller to discharge some quantity of slurry to lower the water level inside the generator when the water level tends to rise above the maximum level.
As soon as the level of water goes down the slurry discharge valve automatically closes. Thus only minimum quantity of slurry is discharged at a time. Water inside the generator absorbs certain quantity of acetylene and hence this water already saturated with acetylene should not be discharged continuously or in large volume but should be retained inside the generator and thus prevent loss of acetylene with the slurry.

The agitator is continuously driven when the carbide feed motor is running. However, when the generator is in dormant state and there is no carbide feed, there is a tendency of the slurry to settle down and jam the agitator. A timer controlled electric motor drive keeps the agitator under operation when the generator is in dormant state. Thus slurry is always kept mixed with water without sedimentation. The agitator is a very important part of the generator as it keeps the carbide and water intimately mixed for total reaction of the carbide and thus prevent a loss of carbide in the form of solids with the slurry.

Passage of acetylene gas from the generator to the carbide chamber (hopper) under filling is kept shut off by hydraulically operated shut off device which operates automatically when the carbide in the hopper is exhausted and screw feed motor is stopped.

The generated acetylene passes from the generator chamber through Wet Type Flash Back Arrestors and then reaches Low Pressure Condenser where the temperature of gas is lowered by cooling water and part of the moisture in the acetylene gas is taken out in the form of waster by condensation. Gas then passes through low pressure dryer filled with calcium chloride to remove further quantities of moisture from acetylene gas before the gas reaches purifying chamber.

Gas is then passed into purifying chamber with optimum quantity of moisture in the gas (gas is not completely dry). Purifying chamber is filled with purifying chemicals to remove Phosphorus and Sulphur compounds from the gas and if necessary to remove acidic fumes also.

Thereafter gas passes to water filled scrubber where acetylene gas is washed with water to remove particles of purifying chemicals which may be carried over with the gas from purifying chamber. The wet gas then enters suction of acetylene compressor, compressed and passed to high pressure dryer filled with mechanical devices and chemicals to remove lube oil vapour and moisture from the gas. Gas after passing through the High Pressure Dryer is arrested by Back Pressure Valve on the pipeline leading to the manifold. Back Pressure Valve is set at a pressure between 12 to 14 kg/cm² so that no gas till the pressure rises above the set pressure is allowed to pass on to the manifold.

This ensures efficient drying of acetylene gas in the high pressure dryer. Thereafter gas passes through Dry type Flash Back Arrestor to manifold and then passes to the cylinders hooked on the manifold through Static Free Uniflow Valves meant for each cylinder.
Besides producing acetylene gas, the process also yields a by-product of a hot solution of Calcium Hydroxide (Ca(OH)\(_2\)) or slaked lime, this is planned to be stored on site and sold for use in other sectors (i.e. agriculture).

_Figure 5.1_ and _Table 5.1_ present a typical Process Flow Diagram of an Acetylene Gas manufacturing facility such as that which Air Products proposes to install at their new site.

_Figure 5.2_  **Schematic of a Typical Acetylene Gas Facility**

![Schematic of a Typical Acetylene Gas Facility](image)

_Source: Air Products South Africa (Pty) Ltd (November 2013)_

<table>
<thead>
<tr>
<th>No.</th>
<th>Component</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acetylene generator</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>Carbide filler hopper manifolds</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Hoist</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>Cooler condenser</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Low pressure drier</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Acetylene purifier</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>Scrubber</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>Acetylene compressor panel</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>High pressure driers</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>High pressure filler</td>
<td>20</td>
</tr>
</tbody>
</table>

_Monitor_  
_Acetone pump_  
_Drainback manifold_  
_Air compressor_  
_Master control_  
_Mercoid switch_  
_Flame arrestor_  

_Source: Air Products South Africa (Pty) Ltd (November 2013)_:
**Cylinder Filling**

Acetylene is supplied to customers in cylinders which are filled with acetone and packing rings and the acetylene is dissolved in this liquid. Before cylinders are weighed for filling with acetylene, or charged with acetone, it must be determined if they are suitable for service and can be safely filled.

Cylinders are not filled if they show evidence of fire damage, serious dents in the shell, shell splits or cuts, shell bulged, damaged seams, stencil weight not legible, broken or missing foot-rings, damaged valves or fusible plugs, and that the cylinder is within test date.

Before hooking the cylinders on the manifold for filling they are weighed on a balance, Acetone content is added, if necessary, by means of a pump and a flexible filler hose with quick shut off type valve and then only the cylinders are made ready for connecting to the manifold for filling.

Cylinders are connected to a manifold and purged with nitrogen (at a pressure 200 kPa) to rid the cylinder of any air. Then the cylinders are pressurised with acetylene to purge the nitrogen.

A water spray is used to cool the cylinders as there is a temperature rise of cylinder during filling operation and absorption of gas in acetone is better when the gas is at a lower temperature. The water spray also acts as leak inspection during acetylene filling. Cylinders are filled to a pressure of 2,200 kPa (22 bar).

When the cylinders are filled to the desired pressure as per temperature chart, filling is stopped and acetylene gas is allowed to settle inside cylinders. There will be some drop in pressure and a second or third filling may be necessary to achieve the desired cylinder pressure.

After filling cylinders are taken out by disconnecting the pigtails, cylinders weighed on weighing machine and quantity of acetylene filled in the cylinders is ascertained from the weight of the cylinders. Cylinders are tested for leaks and stored for distribution.
Hazards of Acetylene

Acetylene (systematic name: ethyne) is the chemical compound with the formula $\text{C}_2\text{H}_2$. It is a hydrocarbon and the simplest alkyne. This colourless gas is widely used as a fuel and a chemical building block. It is unstable in pure form and thus is usually handled as a solution. Pure acetylene is odourless, but commercial grades usually have a marked slight garlic odour due to impurities. As an alkyne, acetylene is unsaturated because its two carbon atoms are bonded together in a triple bond.

Acetylene is an extremely flammable gas that is transported in cylinders packed with a porous filler material and acetone liquid. The Acetylene gas is dissolved in the Acetone. Acetylene is classed as an extremely flammable gas and may form explosive mixtures in air if released to the atmosphere. Immediate fire and explosion can occur when mixed with air at concentrations exceeding the lower flammable limit of 2.4 % v/v.

Physical properties

At atmospheric pressure, acetylene cannot exist as a liquid and does not have a melting point. The triple point on the phase diagram corresponds to the melting point (~80.8 °C) at the minimum pressure at which liquid acetylene can exist (1.27 atm). At temperatures below the triple point, solid acetylene can change directly to the vapour (gas) by sublimation. The sublimation point at atmospheric pressure is ~84 °C.

The adiabatic flame temperature in air at atmospheric pressure is 2,534 °C. Acetylene gas can be dissolved in acetone at room temperature and 1 atm. Approximately 20 percent of acetylene is supplied by the industrial gases industry for oxy-acetylene gas welding and cutting due to the high temperature of the flame; combustion of acetylene with oxygen produces a flame of over 3,300 °C, releasing 11.8 kJ/g. Oxy-acetylene is the hottest burning common fuel gas.

Oxy-acetylene welding was a very popular welding process in previous decades; however, the development and advantages of arc-based welding processes have made oxy-fuel welding nearly extinct for many applications. Acetylene usage for welding has dropped significantly.

On the other hand, oxy-acetylene welding equipment is quite versatile – not only because the torch is preferred for some sorts of iron or steel welding (as in certain artistic applications), but also because it lends itself easily to brazing, braze-welding, metal heating (for annealing or tempering, bending or forming), the loosening of corroded nuts and bolts, and other applications. Oxyacetylene welding may also be used in areas where electricity is not readily accessible.

As well, oxy-fuel cutting is still very popular and oxy-acetylene cutting is utilized in nearly every metal fabrication shop. For use in welding and cutting, the working pressures must be controlled by a regulator, since above 15 psi acetylene will decompose explosively into hydrogen and carbon.
Acetylene is not especially toxic but when generated from calcium carbide it can contain toxic impurities such as traces of phosphine and arsine. It is also highly flammable (hence its use in welding). Its singular hazard is associated with its intrinsic instability, especially when it is pressurized. Samples of concentrated or pure acetylene can easily react in an addition-type reaction to form a number of products, typically benzene and/or vinyl acetylene.

These reactions are exothermic, and unlike other common flammables, do not require oxygen to proceed. Consequently, acetylene can explode with extreme violence if the absolute pressure of the gas exceeds about 200 kPa. Most regulators and pressure gauges on equipment report gauge pressure and the safe limit for acetylene therefore is 101 kPa gauge. It is therefore shipped and stored dissolved in acetone contained in a gas cylinder with a porous filling (agamassan), which renders it safe to transport and use, given proper handling.

Copper catalyses the decomposition of acetylene and as a result acetylene should not be transported in copper pipes. Brass pipe fittings should also be avoided.

- Boiling Point: -84.2°C
- Relative Density Vapour: 0.899
- Auto Ignition Temp: 325°C
- LFL: ~ 2.4% v/v
- UFL: ~ 83% v/v
- Extremely flammable gas

**Hazards of Nitrogen**

Nitrogen is a colourless, odourless and chemically inert gas under normal atmospheric conditions. At atmospheric pressure and at temperatures below -196°C it is a colourless liquid, slightly less dense than water. Large volumes of nitrogen are normally stored and handled in this liquefied (cryogenic) state.

**Physiological Effects**

The main hazard associated with nitrogen in common with other inert gases is that of asphyxiation due to oxygen deficiency. Whilst in the case of a healthy person on short exposure survival is possible at an oxygen content as low as approximately 13%, no person should ever be asked to endanger their life by breathing such an atmosphere. An insidious feature of oxygen deficiency is that it cannot readily be detected by the senses, and victims are usually unaware of the danger they are in and many have a feeling of well-being.

Human beings vary considerably in their reactions to oxygen deficiency, and it is therefore not possible to lay down hard and fast rules as to how people will react. A general indication of what is liable to happen is given in the table below, but it should be appreciated that the reactions of some individuals may be very different from those shown, and may be increased by the presence of other gases especially carbon dioxide.
Table 5.2  Effects and Symptoms of Oxygen Deficiency

<table>
<thead>
<tr>
<th>Oxygen Content (Vol %) (at atmospheric pressure)</th>
<th>Effects and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 %</td>
<td>Normal oxygen content in air.</td>
</tr>
<tr>
<td>12 % - 16 %</td>
<td>Breathing and pulse rate increase, muscular co-ordination slightly disturbed, diminution of physical and in intellectual performance without person's knowledge</td>
</tr>
<tr>
<td>10 % - 14 %</td>
<td>Emotional upset, abnormal fatigue, disturbed respiration.</td>
</tr>
<tr>
<td>6 % - 10 %</td>
<td>Nausea and vomiting, collapse or loss of consciousness within a few minutes, resuscitation possible if carried out immediately.</td>
</tr>
<tr>
<td>&lt; 6 %</td>
<td>Fainting almost immediate, convulsive movements, possible respiratory collapse and death.</td>
</tr>
</tbody>
</table>

In general, oxygen deficiency leads to loss of mental distortion in a relatively short time and considerable brain damage and death.

The harm criteria for spillage of Nitrogen utilised in this assessment are presented in the following table.

Table 5.3  Nitrogen Harm Criteria used in this Report

<table>
<thead>
<tr>
<th>Total Oxygen Concentration in the Air (%)</th>
<th>Excess Asphixiant Concentration (%)</th>
<th>Fatality Level Pfat</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>47.6</td>
<td>0.01</td>
</tr>
<tr>
<td>10</td>
<td>53.5</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>61.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The following plot plan shows the preliminary layout plan for the site.
Figure 4.2  Conceptual layout plan
5.1.1 **Bulk Storage Facilities**

The following chemicals will be stored on the proposed Air Products site:-

**Calcium Carbide**

Turnbins containing calcium carbide (raw process material) will be stored in a covered storage facility to prevent moisture from entering the turnbins. This storage facility is approximately 96m³ with an area of 9 m x 12 m.

**Nitrogen Storage**

A nitrogen storage tank will installed adjacent to the calcium carbide storage facility. The capacity of the nitrogen tank will be 20 m³.

**Acetone Storage**

The acetone storage tank will be installed adjacent to the nitrogen tank and will have a capacity of 20m³.

**Acetylene Gas Cylinder Storage**

The filled acetylene gas cylinders will be stored on-site for distribution. It is expected that 10 000 gas cylinders will be filled per month. At any one time, approximately 100 gas cylinders will be stored on site. There will be designated storage areas for gas cylinders which are empty (dropped off) and gas cylinders which are full (to be collected).

**Fuel and Lubricants**

Other fuels, lubricants and solvents used for the process equipment or other equipment will be stored on site. These include diesel, oils and cleaning agents for maintenance activities. These chemicals will be stored in a bunded and secured area, within the stores, located adjacent to the maintenance and workshop facilities.

5.2 **DESCRIPTION OF PRODUCTS STORED ON SITE**

The characteristics of acetylene and acetone flammable products and the nitrogen asphyxiant product on site considered for the MHI appear in their respective Material Safety Data Sheets (MSDS). Copies of the MSDS’s are attached as Annex C.
5.3 **POPULATION DATA**

Both individual and societal risks were addressed in this assessment (refer to Section 6.3). In order to do so, it was necessary to identify average populations at various locations surrounding the proposed site.

Where site specific population data was not available were assigned populations based on population densities defined by the TNO Green Book. The population densities for various designations of areas are shown in Table 5.4. It has been concluded that the surrounding area matches the description of a sporadic residential development and the industrial developments classed as low personnel density (highlighted in Table 5.4).

**Table 5.4 Populations Densities for Areas Surrounding Proposed Air Products Site**

<table>
<thead>
<tr>
<th>Type of area</th>
<th>Description</th>
<th>Population density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential areas/habitats</td>
<td>Wildlife area</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Rural area</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Sporadic residential development</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Quiet residential area</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Busy residential area</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Urban development with high-rise buildings</td>
<td>120</td>
</tr>
<tr>
<td>Industrial areas</td>
<td><strong>Personnel density low</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Offices – high-rise buildings</td>
<td>200</td>
</tr>
<tr>
<td>Recreational areas (in season)</td>
<td>Campsite, holiday park</td>
<td>60-200</td>
</tr>
</tbody>
</table>

6 APPROACH TO THE ASSESSMENT

6.1 TERMINOLOGY

*Individual Risk:* The frequency at which an individual may be expected to sustain a given level of harm from the realisation of specific hazards. It is a measure of the risk of harm to an individual with defined characteristics at a given point.

*Maximum Individual Risk:* The individual risk to persons exposed to the highest risk in an exposed population.

*Risk Contours:* Lines that connect points of equal risk around the facility or installation (also known as risk iso-lines).

*Risk Notation:* The numerical expression of risk. Risk assessment results involve small numbers and so an exponential notation or a scientific notation is often used. A ‘unit conversion table’ is presented in Table 6.1.

**Table 6.1 Risk Notation Conversion Table**

<table>
<thead>
<tr>
<th>Exponential/scientific</th>
<th>Power</th>
<th>Decimal</th>
<th>Chance per Million (cpm)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 E-05/yr</td>
<td>1x10^-5/yr</td>
<td>0.00001/yr</td>
<td>10 cpm</td>
<td>1 in 100 000 per year</td>
</tr>
<tr>
<td>1 E-06/yr</td>
<td>1x10^-6/yr</td>
<td>0.000001/yr</td>
<td>1 cpm</td>
<td>1 in million per year</td>
</tr>
<tr>
<td>1 E-07/yr</td>
<td>1x10^-7/yr</td>
<td>0.0000001/yr</td>
<td>0.1 cpm</td>
<td>1 in 10 million per year</td>
</tr>
</tbody>
</table>

In this assessment the chance per million (cpm) notation is generally used in figures and graphs.

6.2 HARM CRITERIA

6.2.1 Thermal Radiation

One of the causes for harm to people considered in this study is thermal radiation, which occurs as a result of a fire. The vulnerability of people exposed to thermal radiation depends on the intensity of the incident radiation and the duration of exposure.

Thermal flux values are used as criteria for long duration fires such as pool fires as well as jet fires and thermal dose values are used for short duration intense fires such as boiling liquid expanding vapour explosions (BLEVEs) and fireballs.
Fatality Criteria

Thermal Flux impact criteria chosen to be used in the fatality assessment have been selected based on the effects of thermal radiation summarised in Lees (1) and have been reproduced in Table 6.2.

<table>
<thead>
<tr>
<th>Thermal Flux (kW.m⁻²)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>Intensity at which damage is caused to process equipment</td>
</tr>
<tr>
<td>12.5</td>
<td>Intensity at which piloted ignition of wood occurs</td>
</tr>
<tr>
<td>6.3</td>
<td>Intensity in areas where emergency actions lasting up to 1 minute may be required without shielding but with protective clothing</td>
</tr>
</tbody>
</table>

The UK HSE has developed criteria based on a research report (2) that used the following relationship to calculate the thermal dose:

\[ tdu = T \left(\frac{F}{tdu}\right)^{4/3} \]

where:
- \( tdu \) = thermal dose units \([\text{kW/m}^2]^{4/3}\) \(\text{s} \)
- \( T \) = time (s)
- \( F \) = Thermal flux (kW/m²)

This report uses the HSE thermal radiation impact criteria for short duration fires that are chosen based on the effects described in Table 6.3.

<table>
<thead>
<tr>
<th>Thermal Dose (tdu)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>50% fatalities among a ‘typical’ population</td>
</tr>
<tr>
<td>1000</td>
<td>Dangerous dose to a ‘typical’ population – equates to approximately 1% fatalities</td>
</tr>
<tr>
<td>500</td>
<td>Dangerous dose to a vulnerable / sensitive population</td>
</tr>
</tbody>
</table>

6.2.2 Explosion Overpressure

Vapour cloud explosions (VCEs) can injure people directly or cause damage to buildings which can further cause injury or death to people from debris. From data provided by the UK HSE (3) and the TNO Green Book (4), for blast injuries and damage to building structure Table 6.4 has been generated.

---

It can be seen that overpressure levels required to harm people directly are significantly greater than levels required to damage structures (e.g. an overpressure of around 50 kPa would be sufficient to destroy a house but would be below the threshold for lung damage).

This means that fatality probabilities for people outdoors tend to be less than those for people within buildings, where secondary blast effects (the structures collapsing on the occupants) may cause injury or fatality.

Fatality Criteria

Based on the information above, the impact criteria selected for the fatality assessment is shown in Table 6.4.

### Table 6.4 Blast Fatality Impact Criteria

<table>
<thead>
<tr>
<th>Explosion Overpressure (kPa)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Almost complete destruction of typical masonry structures. Significant damage to steel frame structures.</td>
</tr>
<tr>
<td>20</td>
<td>Deformation of structures like pipe bridges, steel frames. Serious damage to masonry structures.</td>
</tr>
<tr>
<td>5</td>
<td>Minor damage to masonry structures. Conventional windows broken.</td>
</tr>
</tbody>
</table>

6.2.3 Flash Fire Flammability Limit

The extent of a Flash Fire is defined by dispersion of material vapour until the lower flammability limit (LFL) is reached. Within the $\frac{1}{2}$ LFL contour there is still a possibility of fatality due to exposure to burning pockets of vapour. Therefore dangerous dose end point criteria for flash fires have been designated as the extent to the LFL and half LFL.

### Table 6.5 Fatality Flash Fire Impact Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFL</td>
<td>Vapour is able ignite and produce a flash fire</td>
</tr>
<tr>
<td>$\frac{1}{2}$ LFL</td>
<td>Burning pockets of vapour can still occur</td>
</tr>
</tbody>
</table>

6.2.4 Fatality Probabilities

**Thermal Radiation**

Based on the impact criteria described in Sections 6.2, fatality probabilities have been assigned based on the information below and are summarised in
Asphyxiant

The harm criteria for spillage of Nitrogen utilised in this assessment are presented in the following table.

**Table 6.9 Nitrogen Harm Criteria used in this Report**

<table>
<thead>
<tr>
<th>Total Oxygen Concentration in the Air (%)</th>
<th>Excess Asphixiant Concentration (%)</th>
<th>Fatality Level Pfat</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>47.6</td>
<td>0.01</td>
</tr>
<tr>
<td>10</td>
<td>53.5</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>61.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The following Table contains the various end-point criteria for the fatality calculations for the various consequence scenarios possible on the proposed Air Products Acetylene Plant.

Table 6.10.

To assign a probability of fatality to people exposed to the thermal flux values in Table 6.2, probabilities of fatality have been assigned based on the required time to reach thermal doses and the probability of fatality that the HSE has assigned to these thermal doses shown in Table 6.3. Information on the time taken to reach a given thermal dose level at different levels of thermal flux is given in Table 6.6.

**Table 6.6 Thermal Dose Impact Criteria**

<table>
<thead>
<tr>
<th>Thermal Flux (kW.m⁻²)</th>
<th>Time to 1800 tdu (s)</th>
<th>Time to 1000 tdu (s)</th>
<th>Time to 500 tdu (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>14.5</td>
<td>8.0</td>
<td>4.0</td>
</tr>
<tr>
<td>12.5</td>
<td>62.0</td>
<td>34.5</td>
<td>17.2</td>
</tr>
<tr>
<td>6.3</td>
<td>154.7</td>
<td>85.9</td>
<td>43.0</td>
</tr>
</tbody>
</table>

At a thermal flux of 37.5 kW.m⁻²:

- For outdoor, a high thermal dosage (1800 tdu) is reached rapidly offering little chance of escape and leaving a high probability of fatality.
- For indoor, although a building may offer some degree of protection, as 37.5 kW.m⁻² is above the spontaneous ignition threshold of wood (1), there is a high probability that the building will catch fire and force occupants to escape into a higher thermal flux field resulting into a high probability of fatality.

At a thermal flux of 12.5 kW.m⁻²:

---

For outdoor, a thermal dose of 1000 tdu is reached after 30 seconds and 1800 tdu after 1 minute, leading to a fatality probability of 1% and 50% respectively. This offers some chance of escape at this level.

For indoor, piloted ignition of wood is possible during long exposure at this thermal flux causing a building to catch fire. However, even if the building does ignite, there is still possibility of the occupants escaping to alternative shelter.

At a thermal flux of 6.3 kW.m\(^{-2}\):

- For outdoor, a thermal dose of 1500 tdu is reached after 1.5 minutes seconds and 1800 tdu after 2.5 minutes, leading to a fatality probability of 1% and 50% respectively. This offers a chance of escape resulting in a low fatality.
- For indoor, thermal flux levels are below the piloted ignition threshold for wood and therefore the likelihood of fatality for building occupants is considered to be very low.

### Table 6.7 Fatality Probability for Thermal Effects

<table>
<thead>
<tr>
<th>Thermal Effects</th>
<th>Fatality Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool fire or Jet fire, Flux &gt; 37.5 kW/m(^2) (or within flame boundary if not reached); Fireball, Dose&gt; 1800 tdu (or within flame boundary if not reached);</td>
<td>0.80 1.00</td>
</tr>
<tr>
<td>Pool fire or jet fire, 37.5 kW/m(^2) / flame &lt; Flux &lt; 12.5 kW/m(^2); Fireball, 1800 / Flame&lt; Dose &lt; 1000 tdu</td>
<td>0.25 0.50</td>
</tr>
<tr>
<td>Pool fire or jet fire, 12.5 kW/m(^2) &lt; Flux &lt; 6.3 kW/m(^2); Fireball, 500 &lt; Dose &lt; 1000 tdu</td>
<td>0.00 0.05</td>
</tr>
</tbody>
</table>

### Flash Fires

People outdoors within the LFL envelope will be enveloped by the flash fire and are assumed to be fatally injured. Within the \(\frac{1}{2}\) LFL contour, exposure to burning pockets of vapour is possible leading to a fatality probability of 0.2 is to be assigned. For people indoor, contact with the flame might result in ignition of an engulfed building, endangering occupants. A fatality probability of 0.3 is assigned within the LFL envelope. Beyond the LFL boundary, the likelihood of fatality for persons indoors is considered to be very low.

### Vapour Cloud Explosions

VCEs lead to explosion overpressures which injure people and damage buildings, often injuring the occupants within. The fatality probabilities associated with VCE overpressures are shown in Table 6.8.
**Table 6.8** Fatality Probability for VCEs

<table>
<thead>
<tr>
<th>Explosion Overpressure (kPa)</th>
<th>Fatality Probability Outdoor</th>
<th>Fatality Probability Indoor</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0.01</td>
<td>0.75</td>
<td>Almost complete destruction of typical masonry structures. Significant damage to steel frame structures.</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0.45</td>
<td>Deformation of structures like pipe bridges, steel frames. Serious damage to masonry structures.</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0.05</td>
<td>Minor damage to masonry structures. Conventional windows broken.</td>
</tr>
</tbody>
</table>

**Asphyxiant**

The harm criteria for spillage of Nitrogen utilised in this assessment are presented in the following table.

**Table 6.9** Nitrogen Harm Criteria used in this Report

<table>
<thead>
<tr>
<th>Total Oxygen Concentration in the Air (%)</th>
<th>Excess Asphyxiant Concentration (%)</th>
<th>Fatality Level P_{fat}</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>47.6</td>
<td>0.01</td>
</tr>
<tr>
<td>10</td>
<td>53.5</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>61.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The following Table contains the various end-point criteria for the fatality calculations for the various consequence scenarios possible on the proposed Air Products Acetylene Plant.

**Table 6.10** Summary of Fatality Probabilities

<table>
<thead>
<tr>
<th>Impact</th>
<th>Fatality Probability (Peopel Indoors</th>
<th>People Outdoors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pool fire or Jet fire, 37.5 kW/m² (or within flame boundary if not reached); Fireball, Dose&gt; 1800 tdu (or within flame boundary if not reached);</td>
<td>0.80</td>
<td>1.00</td>
</tr>
<tr>
<td>Pool fire or jet fire, 37.5 kW/m² / flame &lt; Flux &lt; 12.5 kW/m²; Fireball, 1800 / Flame&lt; Dose &lt; 1000 tdu</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>Pool fire or jet fire, 12.5 kW/m² &lt; Flux &lt; 6.3 kW/m²; Fireball, 500 &lt; Dose &lt; 1000 tdu</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Explosion Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 kPa</td>
<td>0.75</td>
<td>0.01</td>
</tr>
<tr>
<td>20 kPa</td>
<td>0.45</td>
<td>0.00</td>
</tr>
<tr>
<td>5 kPa</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Flash Fire Effects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>0.30</td>
<td>1.00</td>
</tr>
<tr>
<td>0.5LFL</td>
<td>0.20</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Asphyxiant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess Asphyxiant Concentration 61.9%</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Excess Asphyxiant Concentration 53.5%</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Excess Asphyxiant Concentration 47.6%</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>
6.3 **Assessment Criteria**

The current South African Major Hazard Installation Regulations do not offer criteria to define what level of risk is deemed acceptable. To assist in the decision as to whether the site should be registered as an MHI, an internationally used methodology was applied.

The risk criteria used are based on those adopted by the Health and Safety Executive (HSE) in the United Kingdom. This methodology is internationally recognised and accepted as a basis for risk management.

The HSE has developed different sets of risk criteria for different applications. One role that the HSE fulfils in the UK is to advise on development of land in the vicinity of existing MHIs. For this purpose the HSE uses its so-called land-use planning (LUP) criteria. Another set of criteria is used by the HSE to judge the acceptability of risk from existing MHIs.

These are known as risk tolerability criteria. In this project, a stepwise approach has been taken, as illustrated in and the Figure 6.1 steps taken in this particular assessment are highlighted in 'yellow'.

*Figure 6.1  Approach to Application of Criteria*
The first screening step involves consideration of the consequences of potential accidents. For those activities that are known from ERM’s experience to give a potential for off-site effects, a risk based approach has been used.

Where it is not clear whether an activity has the potential for an off-site effect or not, a screening analysis is performed which determines the distance to dangerous dose (1% fatalities) for worst case events. The results are used to determine whether accidents involving that activity can have an impact on members of the public beyond the site boundaries. Where there is the potential to affect members of the public, then further risk calculations were undertaken.

The risk calculation incorporates both the consequences of potential accidents and the associated likelihood (frequency). In this study, the end-point used has been ‘dangerous dose’. Exposure to a dangerous dose results in 1% fatalities in a typical population. Risks are measured in chances per million per year (cpm) of an individual receiving a dangerous dose or worse.

Another screening test is then applied to see whether further risk studies are necessary. This test involves application of the HSE land-use planning criteria, which compare the nature of the surrounding land-use with the risks produced by the MHI. This test is used to judge whether further, detailed risk assessment studies and application of the risk tolerability criteria would be appropriate.

### 6.3.1 Risk Tolerability Criteria for fatality approach

This is the approach we have utilised for this risk assessment. The HSE risk tolerability criteria are used to judge the acceptability of the risks from existing MHIs. In the HSE tolerability of risk framework, risk levels are divided into three bands of increasing risk, as shown in Figure 6.2.

In the lowest band, within the ‘broadly acceptable’ region, the risk is considered to be insignificant and adequately controlled. Risks that are within the ‘unacceptable’ level fall into the uppermost band. In such cases, either action should be taken to reduce the risk levels, or the activity giving rise to the risk should be halted.

Between the unacceptable and broadly acceptable regions the risk is considered to be tolerable if it is as low as reasonably practicable (ALARP). The risk is ALARP when the cost of any further risk reduction measures would be grossly disproportionate to (i.e. much greater than) the benefits gained.

This is demonstrated in Figure 6.2.

---

6.3.2 Individual Risk of Fatality Criteria

The individual risk is the risk to which a hypothetical person (usually with defined characteristics and behaviour pattern) is exposed. The HSE criteria (1) are stated in terms of individual risk of fatality for two types of hypothetical person: a person who is engaged in the industrial activity under consideration (e.g. an employee); and, a person who is not involved in the activity (e.g. a member of the public).

The HSE has provided individual risk values corresponding to the boundaries between the different regions indicated in Figure 6.2. These are summarised in Table 6.9.

<table>
<thead>
<tr>
<th>Level</th>
<th>Individual Risk to Personnel Engaged in the Activity (/yr)</th>
<th>Individual Risk to People not Engaged in the Activity (/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unacceptable</td>
<td>Greater than 1 in 1,000 (10^{-3})</td>
<td>Greater than 1 in 10,000 (10^{-4})</td>
</tr>
<tr>
<td>Broadly Acceptable</td>
<td>No greater than 1 in 1,000,000 (10^{-6})</td>
<td>No greater than 1 in 1,000,000 (10^{-6})</td>
</tr>
</tbody>
</table>

6.3.3 Societal Risk Criteria

Societal risk can be considered a measure of society’s aversion to accidents with multiple fatalities and/or injuries and should be calculated where large numbers of people may be exposed to individual hazards. With regard to societal risk, the UK Health and Safety Executive (HSE) document \(^{(1)}\) states that:

“…the risk of an accident causing the death of 50 people or more in a single event should be regarded as intolerable if the frequency is estimated to be more than one in five thousand per annum.”

This gives a criterion ‘point’ from which intolerable, tolerable and broadly acceptable regions can be extrapolated when considered in conjunction with individual risk criteria. It should be noted that:

- Taken in context, the criterion refers to fatalities among members of the public from accidents at a ‘single major industrial activity’; and
- The criterion appears to be referring to a cumulative frequency (since it refers to ‘50 people or more’) rather than the single value associated with a single release outcome.

With this in mind, the following extrapolations have been performed:

- The criterion for workers at the site is taken to be ten times higher than that for members of the public, i.e. – the risk of an accident causing the death of 50 workers or more should be regarded as intolerable if the frequency is greater than one in five hundred per annum;
- The broadly acceptable region is taken to be two orders of magnitude lower than the criterion point for members of the public, i.e. - risk of an Accident causing the death of 50 people or more is taken to be broadly acceptable if the estimated frequency is less than one in 500,000 per annum; and
- Each individual point is plotted on a graph and criterion lines extrapolated through them, to give the Cumulative Frequency (F) – Number of Fatality (N) criteria lines shown in Figure 6.3.
6.4 METHODOLOGY

The source term and thermal radiation analyses were undertaken using the DNV Phast v6.7 package. This package has been developed by DNV and has been used extensively globally for modelling such incidents. The software package integrates a suite of programmes to perform consequence calculations related to release events and quantifies the resulting hazardous effects and calculates the impact at a specified distance or target.

The ViewRisk risk summation package (developed by ERM) was used for the summation, analysis and presentation of risks related to the installations. The results from the consequence analysis were used as inputs to calculate risks for every scenario.

Consequence dimensions are expressed in terms of a number of parameters as illustrated in Figure 6.4.
Figure 6.4  Harm Envelope Dimension Parameters
7.1 HAZARD IDENTIFICATION

The main hazards associated with the manufacture, storage and handling of acetylene are pool fires resulting from the ignition of released acetone as well as explosions and flash fires resulting from the ignition of a flammable cloud formed in the event of a release of acetylene or acetone.

The pool fire hazards may be realised following acetone vessel overfilling during transfer from road tankers or leaks/failures in the acetone storage vessel and ancillary equipment such as transfer pumps, metering equipment, etc. all of which can release significant quantities of flammable material on failure. The flash fires and explosions may be realised again following a release of acetone or due to a release of acetylene gas to the atmosphere.

Section 3 previously provided an explanation of the events which may occur as a result of release of flammable material, followed by ignition.

7.1.1 Failure Scenarios

Acetylene Scenarios

The scenarios considered as potential for acetylene releases to the atmosphere included releases from the generator system, the compressors as well as from piping and pigtails in the filling halls. There is also the potential for failures of acetylene cylinders due to failures of the actual cylinders or failures of the valves on the cylinders.

The following representative scenarios for the acetylene releases were considered:

Generator Scenarios
- Catastrophic failure
- 100 mm leak
- 10 mm leak

Compressor Scenarios
- Catastrophic failure
- 25 mm leak

Fill Hall Scenarios
- Line rupture
- 5mm leak on line
- Pigtail rupture
- Pigtail leak
- Cylinder rupture
- Cylinder valve shear
- Cylinder corrosion rupture
- Cylinder corrosion leak

Cylinder Storage Scenarios
- Cylinder rupture
- Cylinder valve shear
- Cylinder corrosion rupture
- Cylinder corrosion leak

Releases of acetylene will normally result in jet fires or Vapour Cloud Explosions.

**Acetone Storage Vessel and Delivery Road Tanker Scenarios**

In addition to overfill, the scenarios considered for the acetone storage vessels were partial/local failures and cold catastrophic failures. Factors that have been identified as having an effect on the integrity of vessels are related to design, inspection, maintenance, and corrosion *(1)*.

The following representative scenarios for the acetone storage vessels were considered:

- Catastrophic failure with release of the entire storage content of the vessel.
- Failure of the vessel with release resulting in a quarter of the bund surface (or the intermediate bund where applicable) being covered; and
- Local failure of a vessel, with holes of 6 mm, 13 mm 25 mm and 50 mm. The release resulted in a maximum of the entire bund being covered with product.

Catastrophic failure of a full vessel is considered as being the ‘worst case’ scenario and would result in the loss of the entire vessel contents within one minute.

An effective pool diameter *(2)* is calculated from the sum of the surface areas of the bund and the unconfined pool created from half the vessel contents overtopping the bund. The unconfined pool diameter was assumed not to exceed 100 m, to provide for the presence of kerbs, slopes, drains and other obstacles.

**Large Flash Fire Consequences**

It is possible that the flammable vapour cloud formed in the event of a large release may not result in an explosion, but rather a large flash fire in the event of ignition.

*(1) AEA Technology, HSE Guidance Document*
*(2) The equivalent diameter is that of a circle whose surface area is equal to that of the pools.*
Small Flash Fire Consequences
In the event of a release under non-calm weather conditions, it is unlikely that an explosion or large flash fire will result. Instead it is more likely that a small flash fire would occur under this type of weather condition.

To determine the extent of a small flash fire during non-calm weather conditions, it was assumed that 20% of the spilled product is vaporised and will disperse. This was modelled using 20% of the maximum fill rate. The flash fire is modelled through simulating the dispersion of the initial cloud to the lower flammability limit (LFL). The damage area then corresponds to the LFL cloud footprint.

Pipework and Pipeline Scenarios
The following representative scenarios for the pipework and pipelines were considered:

- Depending on the diameter of the pipe, release from holes having diameters as indicated in Section 7.
- Pump failure with the failure equivalent to the full bore failure of the outlet pipe
- Flange failure with the failure equivalent to that of a 13 mm diameter hole in the pipe.

It was assumed that failures of pipework inside the acetone storage vessel bunds would result in a bund fire. It is understood that all of the pipework on-site used to transfer product to the storage vessels pass through bund walls.

Therefore, when the product is transferred from a road tanker to a storage vessel or from a pump to the cylinder filling facility, a release resulting from the rupture of this pipework will be driven by both the liquid head in the vessel/road tanker (since the pipework used for vessel filling enters near the base of the vessel) as well as the pump.

It is understood that all of the pumps on site will be able to be shutdown using an emergency stop buttons. Therefore, in the instance of a release from pipework downstream of a pump and assuming that the operator will react efficiently, the pump is assumed to be shut down within 30 minutes.

Generally release rates for this assessment have been taken equal to the initial release rates. Where the flow through a pipe is driven by a pump, the maximum flow rate arising from a leak is set to 150% of the normal flow rate to allow for pump over-speed.

The full list of scenarios investigated the failures and the resulting source releases are given in Annex D.
**Acetone Road Tanker Off-Loading Scenarios**

The following representative scenarios for the acetone road tanker off-loading are considered:

- Catastrophic failure of the road tanker
- Guillotine hose breach
- 15 mm hole in the offloading hose
- 5 mm hole in the offloading hose.

Acetone road tanker off-loading facilities will exist on site. These operations will occur in a drained and partially enclosed area and the frequencies are discussed in Section 5.

Scenarios of flexible hose failures are assumed to result in a pool confined to the off-loading area. The released volume in these scenarios is taken as the volume of a single compartment and due to the presence of an operator during offloading the release time is limited to 5 minutes.

Spillage of acetone resulting from the catastrophic failure of a road tanker is assumed to be unconfined.

**Nitrogen Storage Vessel and Delivery Road Tanker Scenarios**

In addition to overfill, the scenarios considered for the nitrogen storage vessel were partial/local failures and cold catastrophic failures. Factors that have been identified as having an effect on the integrity of vessels are related to design, inspection, maintenance, and corrosion (1).

The following representative scenarios for the nitrogen storage vessel were considered:

- Catastrophic failure with release of the entire storage content of the vessel. It was assumed that 50% of the vessel volume would overtop the bund;
- Failure of the vessel with release resulting in a quarter of the bund surface (or the intermediate bund where applicable) being covered; and
- Failure of the vessels with release resulting in the entire bund being covered with product.
- Local failure of a vessel, with holes of 6 mm, 13 mm 25 mm and 50 mm. The release resulted in a maximum of the entire bund being covered with product.

Catastrophic failure of a full vessel is considered as being the ‘worst case’ scenario and would result in the loss of the entire vessel contents within one minute.

---

(1) AEA Technology, HSE Guidance Document
Nitrogen Road Tanker Off-Loading Scenarios

The following representative scenarios for the nitrogen off-loading road tanker are considered:

- Catastrophic failure of the road tanker
- Guillotine hose breach
- 15 mm hole in the offloading hose
- 5 mm hole in the offloading hose.

Once again these operations will occur in a drained and partially enclosed area and the frequencies are discussed in Section 7.

Scenarios of flexible hose failures are assumed to result in a pool confined in the off-loading area due to the presence of an operator during offloading the release time is limited to 5 minutes.

7.2

**Estimation of Consequences**

7.2.1

**Pool Fires**

There is a risk of an on-site fire associated with the storage and handling of acetone on-site. The thermal radiation could potentially impact members of public in the surrounding areas and employees on-site.

This assessment estimates the effects of thermal radiation from fires on human beings. The associated harm envelopes for the event scenarios are summarised in Annex D. The meteorological characteristics that govern the extent of the thermal radiation zone are described in Section 4.2. As described previously, to account for the presence of kerbs, slopes, drains and other obstacles pool fires were modelled as perfect circles and any unconfined pool diameters are taken to be limited to a maximum of 100 m diameter. Table 7.1 shows the maximum pool fire radiation levels reached on the site for the acetone releases.

### Table 7.1

**Maximum Acetone Pool Fire Consequence Distances (worst weather scenario: D5)**

<table>
<thead>
<tr>
<th>Scenario ID</th>
<th>Description</th>
<th>Pool Diameter (m)</th>
<th>Thermal Flux (kW/m²)</th>
<th>Maximum Downwind distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catastrophic Failure (D8)</td>
<td>11</td>
<td>6.3</td>
<td>40</td>
</tr>
<tr>
<td>Road Tanker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rupture</td>
<td></td>
<td>12.5</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catastrophic Failure (D8)</td>
<td>8</td>
<td>6.3</td>
<td>30</td>
</tr>
<tr>
<td>Storage Vessel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rupture</td>
<td></td>
<td>12.5</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>37.5</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
The Inner (37.5 kW/m²) Middle (12.5 kW/m²) and Outer zones (6.3 kW/m²) zones do not extend beyond the Air Products site boundaries for pool fire incidents involving the acetone storage vessel or for pool fire incidents involving the acetone off-loading road tanker.
Figure 7.1  Area Enveloped by the Largest Acetone Pool Fire (D5)
7.2.2  Asphyxiant Nitrogen Dispersion

There is a risk of an asphyxiant cloud of nitrogen being released in the event of a loss of containment from the storage vessel on site or from the delivery road tanker and its associated equipment during off-loading.

This assessment estimates the effects of dispersing nitrogen gas from loss of containment on human beings. The associated harm envelopes for the event scenarios are summarised in Annex D. The meteorological characteristics that govern the extent of the dispersion are described in Section 4.2. Table 7.2 shows the maximum downwind distances for nitrogen concentrations of concern from the worst case scenario of a rupture of the delivery road tanker.

Table 7.2  Maximum Nitrogen Dispersion  Distances to Concentrations of Concern
(worst weather scenario: D5)

<table>
<thead>
<tr>
<th>Total Oxygen Concentration in the Air (%)</th>
<th>Excess Asphyxiant Concentration (%)</th>
<th>Fatality Level Pfat</th>
<th>Downwind Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>47.6</td>
<td>0.01</td>
<td>11</td>
</tr>
<tr>
<td>10</td>
<td>53.5</td>
<td>0.1</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>61.9</td>
<td>0.5</td>
<td>8</td>
</tr>
</tbody>
</table>

It can be seen that even the lowest concentration of concern of 47.6 % nitrogen which equates to an oxygen concentration level of 11% does not extend beyond the Air Products site boundaries being reached 11 metres from the release point.

7.2.3  Acetylene Explosion Modelling

One of the main risks on the Air Products site is the loss of containment of acetylene from the Generator, Compressors, the piping and pigtails in the Filling Hall or the cylinders during filling or storage. This loss of containment could result in an explosion.

Explosion calculations were carried out using the TNO Multi Energy model and Early Ignition of the released acetylene flammable gas cloud. The confined strength was taken as 7.

The volume of the proposed single Fill Hall was provided by Air Products as being 735 m$^3$. The mass of acetylene released into the single Fill Hall from a single generator producing 300 Nm$^3$/hr was calculated as being 48.8 kg.

The volume of the proposed double Fill Hall was provided as 1,470 m$^3$. The mass of acetylene released into the double Fill Hall from 2 generators producing 300 Nm$^3$/hr each, in total then 600 Nm$^3$/hr calculated as 97.6 kg.
This assessment estimates the overpressure effects of explosions due to the loss of containment of acetylene from the various different equipment on the site. The associated harm envelopes for the event scenarios are summarised in Annex D. The meteorological characteristics that govern the extent of the dispersion are described in Section 4.2. Table 7.3 shows the overpressures for a number of explosion scenarios, for both Phase 1 and Phase 2 sections of the project.

**Table 7.3 Overpressures from potential Acetylene Explosions**

<table>
<thead>
<tr>
<th>Overpressure in Barg</th>
<th>Effect Criteria</th>
<th>Fatality</th>
<th>Single Fill Hall</th>
<th>Double Fill Hall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>V=735 m³</td>
<td>V=1407 m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>48 kg Acetylene</td>
<td>97.6 kg Acetylene</td>
</tr>
<tr>
<td>Outdoors</td>
<td>Indoors</td>
<td>Distance (m) from Release Point To Overpressure of Concern</td>
<td>84</td>
<td>85</td>
</tr>
<tr>
<td>0.05</td>
<td>0.0</td>
<td>0.05</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>0.20</td>
<td>0.0</td>
<td>0.45</td>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>

| Overpressure in Barg | Effect Criteria | Fatality | Single Compressor Room | Double Compressor Room |
|----------------------|----------------|----------|V=131 m³ | V=262 m³ |
|                      |                |          | 8.7 kg Acetylene | 17.4 kg Acetylene |
| Outdoors | Indoors | Distance (m) from Release Point To Overpressure of Concern | 75 | 94 |
| 0.05    | 0.0     | 0.05     | 26 | 32 |
| 0.20    | 0.0     | 0.45     | 18 | 23 |

| Overpressure in Barg | Effect Criteria | Fatality | Single Generator Failure | Double Generator Failure |
|----------------------|----------------|----------|V=1050 m³ | V=1050 m³ |
|                      |                |          | 70 kg Acetylene | 140 kg Acetylene |
| Outdoors | Indoors | Distance (m) from Release Point To Overpressure of Concern | 150 | 153 |
| 0.05    | 0.0     | 0.05     | 51 | 53 |
| 0.20    | 0.0     | 0.45     | 36 | 37 |

| Overpressure in Barg | Effect Criteria | Fatality | Single Cylinder Storage Area Failure | Double Cylinder Storage Area Failure |
|----------------------|----------------|----------|V=100 m³ | V=100 m³ |
|                      |                |          | 13 kg Acetylene | 13 kg Acetylene |
| Outdoors | Indoors | Distance (m) from Release Point To Overpressure of Concern | 70 | 70 |
| 0.05    | 0.0     | 0.05     | 24 | 24 |
| 0.20    | 0.0     | 0.45     | 17 | 17 |

The detailed results of the consequence modelling are provided in Annex D. The largest distances are plotted over the site in Figure 7.2 for the Phase 1 scenario and Figure 7.3 for the Phase 2 scenario.
It can be seen from the following figures that the 0.20 bar and 0.35 bar overpressures do not extend beyond the Air Products site boundaries. The 0.05 bar overpressure extends some 82 metres beyond the proposed Air Products Acetylene Plant site boundaries to the West, 70 metres beyond the site boundaries to the North, 28 metres beyond the site boundaries to the East and only a few metres beyond the site boundaries to the South for the final double installation.
Figure 7.2  
Areas Enveloped by the Largest Explosion Scenario Phase 1 Single Generator Rupture
Figure 7.3 Areas Enveloped by the Largest Explosion Scenario Phase 2 Double Generator Rupture
7.3 ESTIMATION OF INCIDENTS

7.3.1 Frequency of Storage Vessels, Pipework and Cylinder Failures and also Off Loading Road Tankers

To determine the probability of an incident occurring, the failure rate needs to be modified by the probability of the material finding an ignition source for fire scenarios. The probability of a pool fire occurring in the event of a release is therefore equal to the product of the failure rate and the probability of ignition. The frequency of the release scenarios identified in Section 7.1 is represented in Table 7.4 and Table 7.5. The ignition probability of fires and explosions is dependent on a number of factors including the type of site, the release rate and the type of material released.

Table 7.4 Storage Vessel Event Frequency Data Utilised in the Risk Analysis (1)

<table>
<thead>
<tr>
<th>Failure Type – Vessels</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic vessel failure</td>
<td>$5 \times 10^{-6}$ per vessel year</td>
</tr>
<tr>
<td>Vessel large leak</td>
<td>$1 \times 10^{-5}$ per vessel year</td>
</tr>
<tr>
<td>Vessel small leak</td>
<td>$1 \times 10^{-4}$ per vessel year</td>
</tr>
</tbody>
</table>

Table 7.5 Failure Frequencies for Pipework Utilised in the Risk Analysis (3) (2)

<table>
<thead>
<tr>
<th>Release Hole Size (mm)</th>
<th>Failure Frequency (per metre year) for Pipe Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;50</td>
</tr>
<tr>
<td>3</td>
<td>$1 \times 10^{-5}$</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>$5 \times 10^{-6}$</td>
</tr>
<tr>
<td>1/3 pipe diameter</td>
<td>$1 \times 10^{-5}$</td>
</tr>
<tr>
<td>Full bore</td>
<td></td>
</tr>
</tbody>
</table>

The ignition frequencies have been taken from the OGP report no. 434-6.1 (3) (March 2010).

For scenarios considered inside bunds, Scenario 13 - Tank Liquid 100m x 100m Bund (Liquid release from onshore tank farm where spill is limited by small or medium sized bund) is used; for releases outside bunded areas Scenario 6 - Small Plant Liquid (Liquid release from small onshore plant) is used.

Scenarios involving the Transnet pipeline are associated with Scenario 1 - Pipe Liquid Industrial (Liquid Releases from onshore pipeline in industrial area) for assigning ignition probability.

For low flash point products such as acetone the ignition probabilities are taken as they appear in the OGP report.

(1) OGP Risk Assessment Data Directory Report No 434 – 3, March 2010, Section 2 – Summary of Recommended Data
(2) Failure Rate and Event Data for use within Land Use Planning Risk Assessments – FR 1.3 –Pipework
(3) OGP Risk Assessment Data Directory, Report No. 434-6.1, March 2010
For the case of the proposed Air Products site it is understood that operators will be present at all times during the offloading of acetone.

It is understood that for typical explosions, some level of congestion of the vapour cloud is required. The area surrounding the Air Products site includes light industries, which are unlikely to cause congestion.

**Road Tanker and Equipment Failures during Off-loading**

The Air Products Global EH&S Process Safety Analysis Methods Manual PSAM-5.11 \(^{(1)}\) presents the following failure data for bulk Road Tankers. And these figures have been utilised in this specific study.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Road Tankers/Rail Wagon (on-site)</td>
<td>5e-7 per tanker year multiplied by fractional time on-site and by number of tankers</td>
</tr>
<tr>
<td>Tank (Pressurized) failure (total inventory)</td>
<td>5e-7 per tanker year multiplied by fractional time on-site and by number of tankers</td>
</tr>
<tr>
<td>Tank (Pressurized) large leak (hole largest connection)</td>
<td>5e-7 per tanker year multiplied by fractional time on-site and by number of tankers</td>
</tr>
<tr>
<td>Tow away whilst attached (outflow from both sides of the full bore rupture)</td>
<td>3.5e-2 per operating year (hose) Or 2.6e-4 per operating year (arm)</td>
</tr>
<tr>
<td>Misalignment connection (leak), 10% of nominal diameter up to 50 mm maximum</td>
<td>3.5e-1 per operating year (hose) Or 2.6e-3 per operating year (arm)</td>
</tr>
</tbody>
</table>

**Cylinders, Drums and Bullets**

The Air Products Global EH&S Process Safety Analysis Methods Manual PSAM-5.11 \(^{(1)}\) presents the following failure data for cylinders, drums and bullets. These figures have been utilised in this specific study and are presented in the following table.
### Table 7.7  
**Air Products Cylinders, Drums and Bullets Failure Data**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cylinders</strong></td>
<td></td>
</tr>
<tr>
<td>All cylinders stored upright in penned segregated areas away from vehicle traffic routes, periodically visually checked for condition</td>
<td></td>
</tr>
<tr>
<td>Thick-walled Seamless noncorrosive Cylinder rupture caused by overfill, or mechanical impact or external fire</td>
<td>6.9e-8 per cylinder year</td>
</tr>
<tr>
<td>Thick-walled Seamless corrosive Cylinder rupture caused by overfill, corrosion, or mechanical impact or external fire</td>
<td>6.9e-7 per cylinder year</td>
</tr>
<tr>
<td>Thin-walled Welded corrosive Cylinder rupture caused by overfill, corrosion, or mechanical impact or external fire</td>
<td>6.9e-6 per cylinder year</td>
</tr>
<tr>
<td>Welded noncorrosive Cylinder rupture caused by overfill, or mechanical impact or external fire</td>
<td>1e-7 per cylinder year</td>
</tr>
<tr>
<td>Cylinder valve shear due to mechanical impact (brass or aluminium-silicon-bronze cylinder valve)</td>
<td>8.9e-7 per cylinder year</td>
</tr>
<tr>
<td>Cylinder valve shear due to mechanical impact (stainless steel cylinder valve)</td>
<td>8.9e-8 per cylinder year</td>
</tr>
<tr>
<td>Cylinder valve shear due to mechanical impact (brass “shearless” cylinder valve)</td>
<td>8.9e-8 per cylinder year</td>
</tr>
<tr>
<td>Cylinder valve leak caused by corrosion or wear and tear (minor leak)</td>
<td>9e-5 per cylinder year</td>
</tr>
<tr>
<td>Cylinder valve leak caused by corrosion or wear and tear (major leak)</td>
<td>9e-6 per cylinder year</td>
</tr>
<tr>
<td><strong>Drums &amp; Bullets</strong></td>
<td></td>
</tr>
<tr>
<td>All drums and bullets stored horizontally in segregated areas away from vehicle traffic routes, periodically visually checked for condition</td>
<td></td>
</tr>
<tr>
<td>Welded corrosive Drum rupture caused by overfill, corrosion, mechanical impact or total bolt failure on flanged end, or external fire</td>
<td>6.9e-6 per drum year</td>
</tr>
<tr>
<td>Multiple welded flammable or corrosive drum rupture caused by large external fire</td>
<td>1e-8 per drum year</td>
</tr>
<tr>
<td>Drum valve shear due to mechanical impact</td>
<td>1.4e-6 per drum year</td>
</tr>
<tr>
<td>Drum valve leak caused by corrosion or wear and tear</td>
<td>4.4e-5 per drum year</td>
</tr>
</tbody>
</table>
7.4 **RISK CALCULATION**

The scenario frequencies and consequence results are used within the ERM ViewRisk risk summation package to calculate the individual risk and societal risk associated with the proposed Air Products site.

7.4.1 **Location Specific Individual Risk for the site – Fatality Assessment**

The risk contours presented in this section represent Location Specific Individual Risk (LSIR). It should be noted that the Location Specific Individual Risk (LSIR) relates to an individual who is permanently exposed 24 hours a day 365 days a year. This is therefore an overestimate of the individual risk to personnel or public who may be present at these locations.

Individual risk of fatality contours for persons located outdoors and indoors at 1, 10, 100 and 1,000 chances per million per year (cpm) for the installations were calculated using the fatality probabilities detailed in Section 6.2.4.

*Figure 7.4* represents the location specific individual risks (LSIR) for hypothetical persons located indoors. It can be seen that none of the risk contours extend beyond the proposed Air Products Acetylene Plant site boundaries.

*Figure 7.5* represents the location specific individual risks (LSIR) for persons located outdoors. Once again it can be seen that none of the risk contours extend beyond the proposed Air Products Acetylene Plant site boundaries.

The main reason for the differences in risk levels for those indoors as opposed to those outdoors is primarily due to the fact that the worst case scenarios of explosions involving loss of containment of acetylene gas cause high fatalities to individuals located indoors as opposed to those outdoors due to building collapses.
Figure 7.4  Location Specific Individual Risks of Fatality Contours for Persons Located Indoors
Figure 7.5  Location Specific Individual Risks of Fatality Contours for Persons Located Outdoors
7.4.2 Societal Risk

To calculate societal risks, the release scenarios, associated frequencies of occurrence, the dimensions of consequence for each weather set and stability class probability were entered into ERM’s risk summation package ViewRisk. The format for presenting societal risk data is in the form of FN curves. These curves illustrate the relationship between an incident which causes N or more fatalities and the cumulative frequency (F) of such an event for the population areas as identified previously.

Societal Risk for Air Products Proposed site

The calculated societal risk results for off-site populations (i.e. excluding known on site populations) as a result of risks posed by the site are so low in this case that an FN curve is not generated. Rate of Harm (Contributors to the Risk)

The Rate of Harm (also known as the Potential Loss of Life, PLL, or Expectation Value, EV) is the sum of the number of people harmed multiplied by the frequency with which this happens. The Rate of Harm breakdown indicates those scenarios which are the largest contributors to the risk. The Rate of Harm breakdown for the site is presented in Table 7.8.

Table 7.8 Rates of Harm Contributing Greater than 1%

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Rate of Harm</th>
<th>Rate of Harm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator Room</td>
<td>VCE after rupture of Generator in Phase No. 2</td>
<td>6.52E-01</td>
<td>90.16</td>
</tr>
<tr>
<td>Generator Room</td>
<td>VCE after rupture of Generator in Phase No. 1</td>
<td>7.11E-02</td>
<td>9.83</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>1.50E-04</td>
<td>0.01</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7.23E-01</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The Rate of Harm breakdown indicates that approximately 99.99% of the largest total risks are as a result of VCEs resulting from ruptures of the Acetylene Generators.
7.5 **ESCALATION EFFECTS**

No escalation effects (i.e. a minor incident escalating to a major incident) are considered in this risk assessment. It is judged that escalation impacts (in terms of the immediate effect on people off-site) associated with explosions involving acetylene are unlikely to result in more severe consequences than the original explosion.
There were no Major Hazardous Installations in the vicinity of the proposed Air Products Acetylene Plant site.
EMERGENCY PLANNING

As this Air Products site is still in the detailed design phase of the project no Emergency Response Plan currently exists. The Air Products site Emergency Response Plan (ERP), when compiled is required to be included within the MHI assessment, as Annex E.

This ERP plan will have to be compiled to take into account of the findings of this risk assessment and must comply with the regulations as outlined in Section 9.1.

The potential consequences of the incidents identified in this assessment should be discussed with the local Emergency Services and the Air Products personnel with the ERP being revised as a result of the discussions where necessary.

It is recommended that the ERP is maintained and tested regularly. The Local Emergency Services and the adjacent industries should also be kept informed of Air Products emergency plans, and included in future trial emergency drills.

9.1 MAJOR HAZARD INSTALLATION REGULATIONS, SECTION 6 - ON SITE EMERGENCY PLAN

Section 6 of The Major Hazard Installation regulations; outline the requirements for on-site emergency planning. All of these points must be complied with by Air Products within the ERP.

“6.(1) An employer, self-employed person and user shall after submission of the information contemplated in regulation 3 (4) –

a) establish an on-site emergency plan to be followed inside the premises of the installation or part of the installation classified as a major hazard installation in consultation with the relevant health and safety representative or the relevant health and safety committee;

b) discuss the emergency plan with the relevant local government, taking into consideration any comment on the risk related to the health and safety of the public;

c) review the on-site emergency plan and where necessary, update the plan, in consultation with the relevant local government service at least once every three years;

d) sign a copy of the on-site emergency plan in the presence of two witnesses, who shall attest the signature;

e) ensure that the on-site emergency plan is readily available at all times for implementation and use;
f) ensure that all employees are conversant with the on-site emergency plan; and

g) cause the on-site emergency plan to be tested in practice at least once a year and keep a record of such a test.”
10 CONCLUSIONS

10.1 CONCLUSIONS

The individual risks of fatality have been calculated for the Air Products proposed Acetylene Plant. The study has shown that the operations have the potential to adversely affect the health and safety of people working on-site as well as members of the public off-site and other workers on other sites in the area.

The largest consequence as a result of an incident at the Air Products site could be caused by an explosion involving a loss of containment from one of the acetylene generator systems. From these potential acetylene explosion the 0.05 bar peak overpressure can extend some 82 metres beyond the proposed Air Products Acetylene Plant site boundaries to the West, 70 metres beyond the site boundaries to the North, 28 metres beyond the site boundaries to the East and only a few metres beyond the site boundaries to the South for the final double installation.

The individual and the societal risk levels posed by the proposed Air Products site, both Phase 1 and Phase 2 of the development, have been shown to be broadly acceptable for members of the public if it can be demonstrated that Air Products has taken measures to ensure the levels of risk are As Low As Reasonably Practicable (ALARP).

For surrounding sites the individual risk of fatality is less than 100 cpm and therefore not considered intolerable. For workers on-site the risks are found to be below 1000 cpm and therefore tolerable if Air Products can demonstrate that they are ALARP.

Environmental Resources Management Southern Africa (Pty) Ltd would declare the Air Products proposed Acetylene Plant located at Tilliet Road, Daleside near Meyerton in the Gauteng Province as a Major Hazard Installation (MHI) as outlined in the current legislation.

As a result of being declared a MHI, the Requirements of the MHI Regulations must be followed completely to ensure the proposed Air Products Acetylene Plant is legally compliant. Copies of this risk assessment must be submitted to the Local Provincial Director of the Department of Labour, the Chief Inspector of the Department of Labour Head Office in Pretoria and the Local Authorities.